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Research Experiences for Teachers and Young Scholars in Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST)

Design of flexible solid state pseudocapacitor for wearable technologies

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Introduction

Capacitors and batteries are devices that both store potential energy. Both devices have both advantages and disadvantages. Some advantages of a capacitor are their ability to cycle a high number of times and ability to deliver a large amount of power very quickly. The research goal for this project was to fabricate a flexible solid state pseudocapacitor that would be useful in wearable devices. These wearable capacitors need to be capable of powering an LED for a minimum of one hour as well as able to be cycled thousands of times with minimal performance loss. Size and cost was also kept in mind throughout the project.

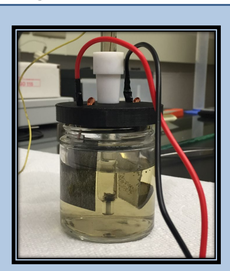


Figure 1

Left: a piece of carbon mesh being coated through electrodeposition.

Right: Comparison of different materials that were coated throughout first RET

Fabrication of Pseudocapacitor Components

Our pseudocapacitors consist of electrodes, a solid state electrolyte and a current collector. Various materials were considered and tried when fabricating the parts of the capacitor. Most of these materials were also used uncoated and then also coated with a polypyrrole coating applied using electrodeposition (Figure 1). Electrolytes were a mixture of polyvinyl alcohol, phosphoric acid and glutaric dialdehyde. Once mixed the solution was cast onto a plastic sheet to dry and set for 48 hours (Figure 2).

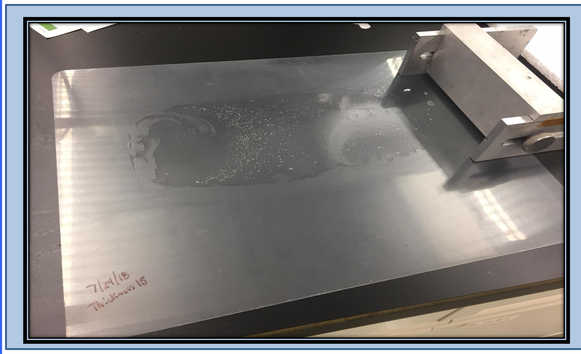


Figure 2
A piece of PVA membrane that was just cast and will need to set and dry

Assembly of Pseudocapacitors

Early prototype pseudocapacitor cells were created making a sandwich using the materials as current collectors, electrodes, and the electrolyte (Figure 3).

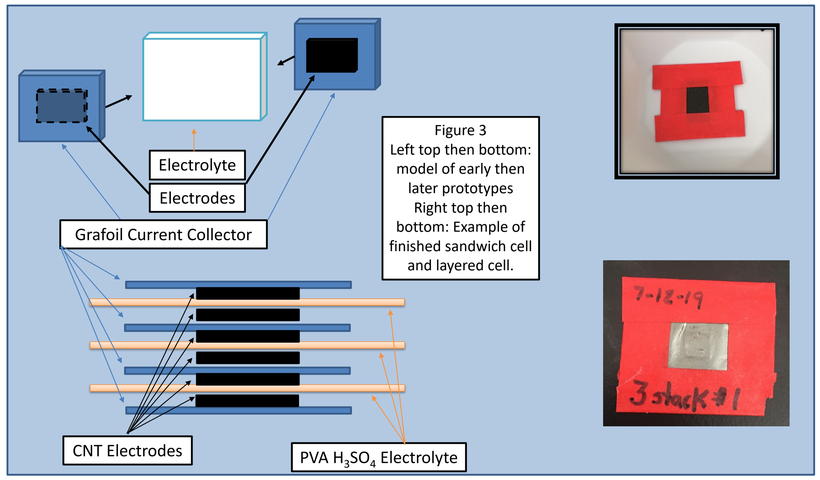
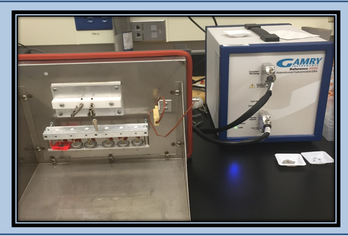


Figure 3
Left top then bottom: model of early then later prototypes
Right top then bottom: Example of finished sandwich cell and layered cell.

Testing



A taped cell that is being tested by pins pressing on the cell

Test 1-Impedance

Impedance is done using Electrochemical Impedance Spectroscopy or EIS. This testing shows the overall resistance of the pseudocapacitor.

Test 2-Capacitance testing

Capacitance testing is done through a cyclic voltammetry test. This testing shows the amount of energy capable of being stored by the pseudocapacitor.

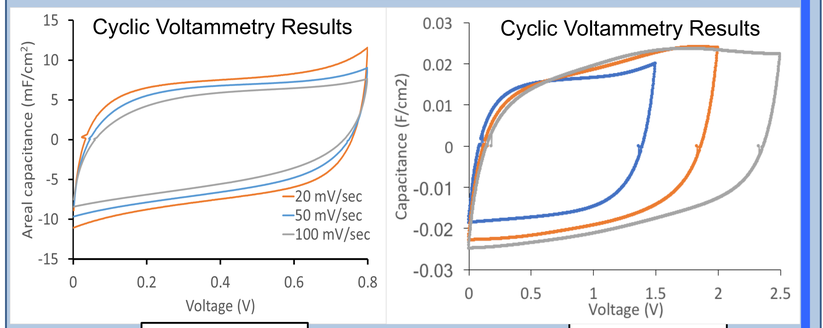
Test 3-Charge/Discharge

During the charge discharge testing we are testing the retention ability of the pseudocapacitor after repeated charges and discharges

Results

Many sample cells were created and then tested in the lab (Figure 5). Early results were encouraging enough to begin stacking the cells for further testing. Some of these cells showed promise for the current ASSIST application among other applications.

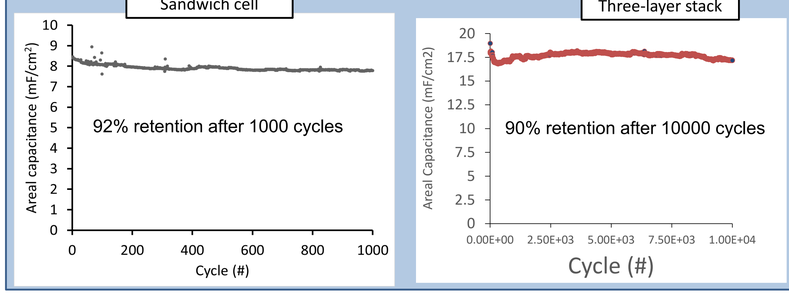
Figure 5:
CV Testing results calculated using the formula
$C(mF/cm^2) = \frac{I\ (mA)}{V(V/s) \times A\ (cm^2)}$



Sandwich cell | Three-layer stack

CD testing results calculated using the formula
$C(mF/cm^2) = \frac{I\ (mA) \times t\ (sec)}{\Delta V \times A\ (cm^2)}$

Sandwich cell | Three-layer stack



Summary with Next Steps

At the time of this poster creation, pseudocapacitors have been fabricated from various materials that achieved and exceeded the capacitance and longevity goals we were looking for. The next step in the research would to begin upsizing the samples and to test the flexibility of the cell to determine if the performance is compromised when bending and manipulating the sample.

Acknowledgements

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